



TENNESSEE DEPARTMENT OF

EDUCATION
FIRST TO THE TOP

STEM Designers

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| Primary Career Cluster: | Science, Technology, Engineering, and Mathematics (STEM) |
| Consultant: | Bethany King Wilkes, (615) 532-2844, Bethany.Wilkes@tn.gov |
| Course Code: | TBD |
| Prerequisite(s): | None |
| Credit: | 1 |
| Grade Level: | 8 |
| Graduation Requirement: | None |
| Coursework and Sequence: | This is the third course in the <i>Middle School STEM</i> sequence of coursework. |
| Necessary Equipment: | Refer to the equipment list found on the STEM website linked below. |
| Aligned Student Organization(s): | Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov |
| Coordinating Work-Based Learning: | N/A |
| Available Student Industry Certifications: | N/A |
| Dual Credit or Dual Enrollment Opportunities: | N/A |
| Teacher Endorsement(s): | 001, 013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 101, 210, 211, 212, 213, 214, 230, 231, 232, 233, 400, 401, 402, 413, 414, 415, 416, 417, 418, 440, 470, 477 |
| Required Teacher Certifications/Training: | Teachers who have never taught this course must attend training provided by the Department of Education. |
| Teacher Resources: | http://www.tn.gov/education/cte/doc/STEMResourceList.pdf |

Course Description

STEM Designers is a fundamental middle school course that trains students to define problems and methodically answer the question, “What is the solution?” Upon completion of this course, proficient STEM designers understand that engineering design is a process of developing solutions to problems and challenges in order to meet the needs of society. Students continue to apply the practices for

science and engineering learned in *STEM Explorers* and *STEM Innovators*; however, *STEM Designers* places more emphasis on practices such as using mathematics and computational thinking; designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information. In addition to gaining a deep understanding of the relationship between engineering and design, students who complete this course will learn how both innovation and engineering design result in new technologies that benefit humans. Standards in this course are aligned with Tennessee Common Core State Standards in English Language Arts & Literacy in Technical Subjects and Tennessee Common Core State Standards in Mathematics.*

Note: Students are expected to use engineering notebooks to document procedures, design ideas, and other notes for all projects throughout the course.

Program of Study Application

This is the third course in the *Middle School STEM* sequence of coursework and prepares students for multiple programs of study in the STEM career cluster. For more information on the benefits and requirements of implementing STEM courses in full, please visit the CTE website at <http://www.tn.gov/education/cte/>.

Course Standards

Safety

- 1) Accurately read and interpret safety rules, including but not limited to rules published by the National Science Teachers Association (NSTA), rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. (TN CCSS Reading 3, 4)
- 2) Identify and explain the intended use of safety equipment available in the classroom. For example, demonstrate how to properly inspect, use, and maintain safe operating procedures with tools and equipment. (TN CCSS Reading 3, 4)

Introduction to Engineering

- 3) Research the history of engineering using textbooks, the websites of professional societies, scholarly narratives, and explain how science, technology, and math have influenced its development. Create a timeline of important engineering milestones, noting the influence of science, technology, and math in the timeline. The timeline may be done via PowerPoint, Prezi, poster, or other graphic format. (TN CCSS Reading 1; TN CCSS Writing 2, 4, 7)
- 4) Research and illustrate the relationship between science, technology, engineering, and math using a flowchart, Venn diagram, or other graphic organizer. Provide an example of a design solution that incorporated at least three of the disciplines and articulate how they each contributed to the design. (TN CCSS Reading 1; TN CCSS Writing 2, 4)
- 5) Research how engineers in various disciplines (such as civil, mechanical, electrical, chemical, biomedical, computer, agricultural, industrial, and aerospace) benefit society through the



products and solutions they design. Write a paper arguing for the discipline that has benefited society the most. Illustrate the claim with specific products and benefits. (TN CCSS Reading 1; TN CCSS Writing 1, 4, 7)

Engineering Design Process

- 6) Evaluate an existing engineering design, such as a local bridge or a famous building, providing evidence from exemplars and design rubrics to justify whether the design meets the specified criteria. Create a presentation explaining how the steps of the design process might have been used to create this feat of engineering, citing historical narratives, published interviews with the architects or engineers involved, and other informational resources. The typical steps of the design process include: identify the problem; identify criteria and specify constraints; brainstorm for possible solutions; research and generate ideas; explore alternative solutions; select an approach; write a design proposal, develop a model or prototype; test and evaluate; refine and improve; create or make a product; and communicate results. (TN CCSS Reading 3; TN CCSS Writing 1, 2, 4)
- 7) Practice exploring alternative solutions in the engineering design process by creating two solutions for an engineering problem. Test each solution and record the test data. Analyze the test data to determine the differences in the quality for the solutions. Write a conclusion that argues which solution is best and explains why. Support the explanation with specific evidence obtained from test results. For example, create a solar vehicle that is designed travel as fast as possible. The two solutions should have a single variable that is changed, for example drive and axle gear ratio, wheel size, or solar panel angle. (TN CCSS Reading 1, 3; TN CCSS Writing 1, 4, 7, 9; TN CCSS Math 8.SP)
- 8) Use the engineering design process and the practices of science and engineering (see specific practices below) to develop a solution for a given engineering challenge. Chronologically document the entire process in an engineering notebook. The engineering notebook should have bound, dated, and numbered pages. Use permanent ink to document notes. For example, design a balsa or basswood bridge that has the best performance ratio, maximum capacity divided by mass of the bridge. Tests can be done of various basic structure designs before creating a final design. This test data should be included in the engineering notebook. A hand or digital sketch should be made of the design. Pictures can be taken throughout the process and included in the engineering notebook. At minimum, address the following science and engineering practices:
 - a. Using mathematics and computational thinking
 - b. Designing solutions
 - c. Engaging in argument from evidence
 - d. Obtaining, evaluating, and communicating information(TN CCSS Reading 3; TN CCSS Writing 4)

Fundamental Sketching and Engineering Drawing

- 9) Present a two-dimensional design idea using freehand sketching, manual drafting, and computer-aided drafting (such as SketchUp or AutoCad). Designs should be made to scale and include dimensions, labels, and notes. At least one of the designs presented should be an orthographic (multi-view) projection. Use basic dimensioning rules and apply understanding of



the use of lines (e.g., object, hidden, center) to inform the design. Sketch principle views of a simple object from the top, bottom, front, back, left side, and right side. For example, create an orthographic projection of a CO₂ dragster or a floor plan for a home. (TN CCSS Reading 3, 4, 7; TN CCSS Writing 4; TN CCSS Math, 8.G)

- 10) Present a 3-D design idea using freehand sketching, manual drafting, and computer-aided drafting (such as SketchUp, SolidWorks, or Inventor). Designs should be made to scale and include dimensions, labels, and notes. Use basic dimensioning rules and apply understanding of the use of lines (e.g., object, hidden, center). *For example, convert the 2-D design in the activity in the previous standard into a 3-D design in the 3-D version of the software used to create the 2-D design.* (TN CCSS Reading 3, 4, 7; TN CCSS Writing 4; TN CCSS Math, 8.G)
- 11) Create a scaled model of a design concept. A digital or manual drafting design should be made of this model prior to building or producing the model. For example, create a digital 3-D design of a product and use a 3-D printer to create a physical model of the design. If a 3-D printer is not available, build a model from materials provided in the class. (TN CCSS Reading 3, 4, 7; TN CCSS Writing 4; TN CCSS Math 8.G)

Final Project

- 12) Work in groups to solve a community or school problem by applying the engineering design process and the practices of science and engineering. Build a prototype, if feasible, and write a technical report detailing the problem, the design process used, and the solution proposed. Include an evaluation of the quality of the solution, and give a presentation to the class. Be able to justify the final design solution with supporting evidence from the process, including graphic representations and visual aids as appropriate. (TN CCSS Reading 1, 3, 4, 7, 9; TN CCSS Writing 2, 5, 6, 7, 8, 9, 10)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: [Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 6-8 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 2, 5, 6, 8, and 10 at the conclusion of the course.
- TN CCSS Writing: [Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 6-8 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 3 at the conclusion of the course.
- TN CCSS Math: [Common Core State Standards for Mathematics](#); Math Standards for Middle School.
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to



collaborate with mathematics educators to design project-based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate mathematical reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.

- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
 - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.
- Achieve: [Next Generation Science Standards](#). (2013). “A Science Framework for K-12 Science Education.”

